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ORGANIC PHYSICS.

BY CHARLES MORRIS.

(Continued from July number.)

BUT it is necessary to more particularly examine this peculiar organic synthesis, through which a germinal cell is produced containing molecular energies derived from every portion of the body. The leucocytes appear to generally answer the requirements, but in an organism so complex as that of the human body, we should naturally look for something more than a mere chance aggregation of cellular germs into a completely generalized germ. Such a process would be most likely to yield few perfectly organized germs, and the production of abnormal should far exceed that of normal embryos. Evidently the continuance of the human species would be impossible unless full provision were made for the complete union of these cellular germs. And if such provision be made, the organs adapted to it can scarcely be invisible to us.

In fact, as we have in the leucocyte an active cellular organism whose duty in the body has been a puzzle to physiologists, so we find organs in the body alike puzzling. And significantly these organs seem devoted only to the formation of leucocytes. They constitute the lymphatic vascular system, and the ductless glands, including those of both the vascular systems of the body.

Physiologically there seems no especial necessity for the lymphatic vessels. Why should there be two separate vascular systems, each permeating every portion of the body, and only joining into one at a single point in their whole extensive course? We know the main purposes of the blood system, but the duty ascribed to the lymphatic system is one that inadequately explains the existence of such an extensive system of vessels. If the blood capillaries exude a blastema for the immediate nutrition of the tissues, and if after nutrition is performed there remains a liquid containing the waste material of the tissues, it certainly seems as if the blood capillaries might be capable of reabsorbing this liquid, and that there would not be required for the duty of conveying it to the blood a second system of vessels equally extensive with that of the veins and arteries.

We should naturally look for some other duty in the lymphatic vessels, while the conveyance of waste should be looked upon as a secondary duty. And such a primary duty may present itself in the formation and conveyance of the leucocytes. If we accept the dogma which has certainly not been disproved, that no new cell arises except as a derivative from some preceding cell, then we must ascribe to the leucocytes a cellular origin. And as they arise in immediate contiguity to the cells of the tissues which are bathed by the lymph, we have some warrant for ascribing their origin to these cells.

If, then, the primary duty of the lymphatic vessels be the formation and conveyance of leucocytes, there must be some sufficient physiologic reason why these corpuscles are not immediately delivered to the blood. If our hypothesis of the duty of the leucocytes be the correct one, it is not difficult to conceive this reason. If the combination of the germinal cells from every tissue into generalized cells be an essential duty of the body, then this union may be mainly performed in the lymphatic vessels, and the lymphatic glands may be organs specially adapted to this purpose.

These glands are very numerous. The body contains in all some 600 or 700 of them. At least one of them occurs upon every lymphatic vessel, and the minute ones on the smaller vessels are succeeded by larger ones on the lymphatic trunk vessels, particularly in the upper arm and thigh, the neck, the intestinal region, &c.

In these glands the flow of the lymph is checked. After passing through them it is much richer in leucocytes than before entering them. Evidently they have some essential connection with the development of the leucocytes. May not their main duty be the union of leucocytes into more generalized cells? In the line of flow of the lymph from every minor locality of the body one of these glands is sure to be encountered. Into this flow the leucocytes, or the undeveloped buds, which have arisen from every minute portion, or every cell of that local region. And within the gland some active process of assimilation takes place, which may be the absorption of undeveloped by developed leucocytes, and a rapid growth in consequence. If so, in every gland would be formed germinal cells representing in their molecular conditions all the tissues of the region feeding that gland. Again, as the minor vessels aggregate to form trunk vessels, other glands appear, into which the leucocytes from local regions are poured. In these the process of combination may be continued, so that the corpuscles which flow from every lymphatic gland will be molecular reproductions of all the tissues which send lymph into that gland. Thus the group of glands in the arm-pit may yield leucocytes representing the whole arm; those in the groin, the whole leg; those in the neck, the whole head, &c.

In such an office we have a sufficient and most important duty for the lymphatic system and its numerous glands. The stream of lymph poured into the blood conveys leucocytes each of which represents in its molecular organization some extensive region of the body. An important duty remains yet to be performed; the combination of these leucocytes into generalized representatives of the whole body. And the blood system has a series of glandular organs which are perhaps devoted to this duty alone.

There are no organs of the body which have been a greater puzzle to physiologists than these ductless glands of the blood vessels, the spleen, thyroid, supra renal, &c. Many efforts have been made to explain them, but all that is really known is, that they favor the growth of leucocytes and cause a decrease in the number of red blood corpuscles. This is the only duty that can be ascribed to the principal of these glands, the spleen. Not the least puzzling thing about them is that they seem to have nothing to do with the health and vigor of the body. They may be extirpated and life go on as before without a check. There is certainly something very significant in this fact. It is incredible that such organs should be utterly without vital office in the body, and it is certain that no other internal portions of the body of the same size could be removed without serious injury. Perhaps if the effect upon the reproductive powers of the extirpation of the spleen had been investigated, some important results might have been discovered, for the action of the ductless glands in the increase of leucocytes appears to indicate that they are concerned solely with reproduction, and have nothing to do with the individual life of the body.

The duty of these closed glands, then, may be that of combining the corpuscular representatives of the different organs into corpuscular representatives of the body as a whole. The disappearance of the red blood cells may indicate a vigorous nutritive action of the leucocytes, and in the rapid and continuous flow of the blood through these glands, the best developed cells may complete their molecular generalization and be prepared for excretion from the body by the reproductive glands, as the germs of independent organisms.

A brief re-statement of the hypothesis here advanced may not be amiss. The human body is a colony of cells arranged into organized tissues. Each cell individually considered pursues its life process independently of all others. Its life duty is simply to assimilate nutriment, grow, and to produce daughter cells with the same functions. The life duty of the whole body is the same, to assimilate nutriment, to grow, and to produce daughter cells capable of going through the same process. And these functions as performed by the individual cells are the bases of the same functions as performed by the whole body. Thus the body has a double duty to perform, to subserve the ends of individual life by growth, and those of race life by reproduction. Coherence of the newly budded cells is the organic agency in the former, freedom of these new cells in the latter. And as each cell is adapted to perform both these duties, so is the body as a whole. It has two complete and separate vascular systems, one devoted to the duty of nutrition of the coherent cells, the other to the nutrition of the free cells. The free cells live their life as independent offspring of the fixed cells. It has also two systems of glands devoted to these two duties; the ordinary blood gland is devoted to eliminating impurities from the blood, elaborating special nutriment, aiding in digestion and otherwise subserving the nutrition of the body; the lymphatic or closed gland performs the same duty for the leucocytes; and each system of vessels aids the duty of the other; the lymphatics by bringing the nutriment into direct contact with the tissues; and the blood vessels by their glandular aid to the nutrition of the leucocytes. The action of the glands is probably little more than one of retardation, and the bringing of the elements which enter them into close contiguity. No doubt the leucocytes assimilate material in the open vessels, but this takes place much more rapidly in the glands. And if the red blood cells are merely devitalized leucocytes, then their disappearance in the spleen may signify an assimilation of their molecules by the leucocytes. Thus the latter become more and more generalized in constitution as they absorb molecules originating in the cells of every portion of the body, and they finally reach the reproductive glands as complete molecular representatives of the body.

These reproductive glands, as a final process, excrete the germinal corpuscles from the body to pursue independently their life development. They are either completely thrown out, or else retained for a time in an organ which communicates with the exterior, and is essentially outside the individual organism. The germ is no more a part of the body in the ovary than is food in the mouth.

In the process we have thus indicated, the chemical synthesis of the germ is completed. From this point a reverse process of analysis sets in; the cell grows, divides, its molecules separate and produce specialized cells, these aggregate into special tissues, and finally the composite germ is analyzed into a specialized body, where a particular tissue represents every specific molecular energy in the germ.

But the germs thus produced are derivatives of the whole body, and therefore have male and female polarities arising from its two sides. In some cases they display a hermaphroditic development without further polarization. But in all the higher animals a more complete polarization is necessary, and is gained by the union of germs from separate sexual individuals. This process is preceded by a very significant one in the germs themselves; they continue their growth in the reproductive organs. In the female cell this is done by the process of budding, the result being the protrusion of one or more buds known as the polar bodies. In the formation of these buds one pole of the nucleus is always concerned, and it is evidently a true process of growth, in which the cell suffers a sexual differentiation, its male energy being budded off in these polar bodies. It is the first step in a hermaphroditic growth process which the germinal cell is not capable of carrying further, perhaps from the fact that all the provided nutriment is retained by the female half of the cell.

A somewhat similar process takes place in the male germ, it being here rather a division than a budding. Thus by a natural continuance of the principle of cell growth, the two sexual germs become specially polarized, and suited to unite into a vigorously polar bisexual germ. This final step of synthesis achieved, analysis immediately proceeds as before. Cell growth, division and specialization set in, and a new organic being arises to replace the two in which its germinal organization was elaborated.

In the process here indicated, we may perceive the fundamental cause of one phase of organic evolution, that of growth. The size attained by an animal must be governed, in some degree at least, by the relations of its nutritive and its reproductive energies. If the coherent tendency is favored by any circumstance, the size of the animal must increase, and its reproductive powers lessen. If the free budding tendency is favored, the opposite result must occur. Giants and dwarfs may be the results of abnormal preponderance of one or the other of these energies. There seems to be a constant tendency to vary in this particular, but the struggle for existence vigorously operates to hinder any continual reproduction of an aberration in size not suited to the best interests of the species. The influences which act upon the species, forcibly oppose aberration and restrain it within safe limits.

One influence tending to this result is that of increased or decreased nutrition. We know that in plants diminished nutrition checks growth and hastens the period of reproduction, while increased nutrition has the opposite effect. Probably the same rule holds good in animals. The cells, not fully fed, may cease to form coherent offspring and send off wandering offspring in search of food, reproductive energy being thus hastened. But if fully fed the principle of coherence may predominate to a later period in life and reproductive energy be decreased.

We may close with the presentation of a deduction of some importance from the foregoing hypothesis. It has a specific bearing upon the question of the origin of species. Darwin's theory is based upon the occurrence of innumerable minute variations, of which the most advantageous are preserved. This theory, while explaining in the main the phenomenon of the origin of species, has met with certain awkward difficulties, and perhaps needs to be pieced out with some adventitious hypothesis capable of filling these blanks. It is also desirable that the cause of these variations should be explained if possible.

One of the main objections to the Darwinian theory is the almost total lack of link forms between species. As a nearly absolute rule we find that species boldly succeeds species without a trace of the steps by which the passage from one to the other was made. The only explanation given of this is that of the imperfection of the geological record, but the implication from all the facts known is, that no linking forms existed—or, at least, not as a rule—but that direct steps from species to species have been made.

Nor is such a method of evolution inexplicable. In fact, Darwin has, perhaps, unnecessarily limited the application of his own principles, in confining the molding influences to minute variations. We know that there are many variations which are far from being minute. Extreme variations are occasionally produced, and marked variations which are capable of hereditary transmission are not uncommon.

The minute variations considered in the Darwinian theory are of universal occurrence. Perhaps no case ever arises of a completely normal birth—of an offspring precisely intermediate in all respects between its parents. Variations in size and vigor of the body as a whole, of the separate organs of the body, of the tissues composing these organs, &c., never fail to occur. There is a constant tendency to deviate from the type. And this tendency is in continual conflict with the opposite tendency produced by the struggle for existence and the necessity of preserving the best adaptation to natural conditions.

These minor variations may be due to variations in polar vigor of the molecules. We have already considered the question of molecular energy, and ascribed it to the degree of chemical polarity. The most vigorously acid or basic molecules must have the most vigorous growth energy. But this chemical polarity is constantly affected by cell division. The cells arising from continued division of a primary cell must differ widely in polarity, ranging from the neutral to the extreme of acid or basic conditions. Perhaps the free buds of the tissue cells may be their most vigorously polar offspring, yet differences cannot but occur in their degree of polarity, and the germinal cell into which they aggregate is perhaps made up of molecules considerably differing in chemical activity. In its evolution the growth vigor of the new tissues must be controlled by the chemical energy of the molecules from which they arise. Hence there may be variations from the parental form in every tissue and organ of the new form. The union of germs of two individuals adds a new element of complication to the case. If the molecules of the bisexual germs constitute poles of a galvanic circuit, there may be as many diverse circuits as there are diverse sets of molecules, and the chemical energy of each circuit will be controlled by the chemical vigor of its weaker pole. In developing there is a tendency to reproduce a normal copy of one parent in one lateral half of the offspring, and the other parent in the other half. But this tendency is checked by the influence exerted by each pole of the germ upon the other, so that the two halves of the body are forced into close though not into exact accordance.

Chemical vigor of the molecules must give special nutritive vigor to the tissues arising from them, and it may also yield a tendency to increased cellular coherence, thus doubly aiding the growth vigor of these tissues, while the weaker tissues may be more inclined to bud off free cells from lack of local nutrition.

It is possible that we have in this diversity of molecular chemical activity in the germ an explanation of the marked physical diversities in the tissues thence arising. But there are many cases of abnormal birth which cannot be ascribed to this cause. These abnormalities are very numerous, and differ widely in degree, but may be all grouped under three classes. In one class there is a deficiency in one or more tissues; in another class there is an excess; in a third class the tissues are normal but are displaced. In all these classes the normal type of the body is distinctly departed from.

Surgical records give abundant cases in each of these classes of anomalies. In the first class are deficiencies of every degree, from a very slight lack of tissue to an extreme deficiency. In some cases the limbs are missing, in some the head, in some the brain, in others parts of the viscera. Here a mere trunk appears without head or limbs. In the extreme case a mere shapeless lump of flesh is produced, destitute of any organic differentiation. A frequent case of deficiency is a lack of tissue in the line of junction of the lateral halves of the body. This causes coalescence of organs. In some cases the eyes coalesce, in some the sides of the nose, in some the jaws, this being sometimes so extreme that the ears are united into one. Similar cases of coalescence occur in the viscera, and in the lower limbs, which unite into one.

The second class of anomalies, that of excess organs, is equally marked. In a not unusual case an extra finger appears on each hand, often accompanied by an extra toe on each foot. From this simple duplication there are cases leading up to the most extreme duplication. Three or four eyes, a double tongue, heart, brain, face, and so on, appear, until every organ is duplicated. In more extreme cases we have duplication of the lower limbs, a double head, the head and part of the trunk double, and finally the whole body double, the two halves being united either intimately or by only a slight bond, like that of the Siamese twins. In some cases a triple body has appeared. These twin formations are not the result of a chance union of developing germs, for a complete series of duplications, from the slightest to the most extreme, are upon record.

Another set of anomalies, that of cleft or division between the lateral halves of the body, may perhaps be included in the same class. An ordinary case of this kind is that of cleft or hare lip, but it is found in every part of the dividing line of the body. The two sexual halves seem to have a tendency to develop separately, and this is perhaps a step in the process of duplication.

The third class of anomalies alluded to is that of displacement of organs. This also is of frequent occurrence. A few instances will suffice for illustration. The twin internal organs, the two kidneys, for instance, sometimes occur on the same side of the body. Of the exterior organs, a case is on record in which the thumb was missing on one hand, while a double thumb appeared on the other. A more striking case is one in which one foot had but a single toe, while the other foot had eight, one of these being partly cleft in indication of the ninth. Another case is that of eleven ribs on one side and thirteen on the other.

These anomalous births may have far more importance than has been ascribed to them; possibly, indeed, they may be of essential significance in the question of the origin of species. But before considering their consequences, it may be well to consider their cause. In doing so it becomes necessary to carry the theory of the struggle for existence further back than is usually done. Ordinarily it is made to apply only to the case of survival of the fittest in mature forms or in well developed embryos. But it may be applied with equal justice to the struggle for existence between germs, or between the leucocytes of the blood. These self-feeding amœboid corpuscles battle for nutriment. It is not probable that they all become fully generalized. Those most fully generalized possess the best nutrient relations to the blood, and are most apt to survive. Those only partly generalized are apt to lose their vitality and become nutriment for more vigorous leucocytes, or for the body tissues.

But many imperfectly developed leucocytes may be excreted by the reproductive glands and pass into the ovaries or the testes. Here a new struggle for existence arises, in which the best developed germs are undoubtedly favored, but in which chance circumstances may give an imperfectly developed one an advantage in the struggle. Where the lack of normality is slight, the chances for development are nearly equal. Where it is great, only abnormal conditions in the reproductive organs can give the abnormal germ the advantage; consequently the production of a considerable anomaly is of rare occurrence.

It is probable that cases of reversion to ancestral types are instances of germinal deficiency. The embryo, in its development, seems to pass through phases resembling every ancestral type of the species, and a partial deficiency of molecular organization in the germ may limit the development of some organ or tissue at the point reached by a more or less remote ancestor. Frequently there are reproduced characteristics of an ancestor a few generations removed. Occasionally there may be of a very remote ancestor. The sexual union of a normal with a deficient germ cannot yield a normal offspring, since the opposite polarities necessary to normal development are only partially present. For this reason every anomaly crosses the lateral line of the body, since the molecules of neither sexual side can develop without aid from those of the other.

As for the anomaly of displacement of organs, its cause is not apparent. The mode of arrangement of the germinal molecules controls the direction of their development, and the normal arrangement is forcibly produced through the action of the special polarities of these molecules. Yet perhaps there is some slight possibility of variation in the position of the molecules in the germ. If so, an exceedingly slight molecular displacement might produce a strongly marked organic displacement in the developed body.

The third class of anomalies, that of duplication, can also be met by a conjectural explanation. It may arise from duplication of leucocytes in the glands; two leucocytes coming from the same region of the body, and passing through the same lymphatic gland, may possibly combine, and thus yield a doubly polar corpuscle. If so, the germ thence arising would have a double, or perhaps a triple polarity in some of its molecules. And this duplication will be more complete as the gland producing it is a more central one. It may vary from the production of a slight duplication of tissue to that of a combination of two fully generalized leucocytes. If such a germ, with part or all of its molecules doubly polar, combine with a germ of the opposite sex and develop, the bisexual germ thus produced would be, to some extent, bipolar at one sexual pole and unipolar at the other. But as each pole exerts a controlling influence upon the development of the other, the result might be a bipolar or a unipolar organism, as one or the other sexual pole was preponderant in energy.

If duplication of organs or of bodies has its origin in the action of the glands upon the development of the leucocytes, as here supposed, this must, in some cases at least, result from abnormal organization of the glands. Only thus can be understood the frequent recurrence of the same malformation out of the same parents; this extending to the extreme case of twin births, which may occur more than once from the same mother.

Having thus offered some conjectural explanations as to the physiological cause of abnormal births, it remains to consider their bearing upon the question of the origin of species.

Abnormal offspring do not succumb without a struggle for life. Twin monstrosities often survive to maturity. A deficiency so extreme as the total lack of a brain does not cause immediate death. Brainless children have survived for some time after birth. Of course the chances are enormously against extreme aberrations from the normal type being transmitted. But slight aberrations are sometimes stubbornly transmitted, particularly if they be such as do not specially affect the life chance of the individual. Thus an extra finger may be sent down through several generations, and undoubtedly could, by intelligent sexual selection, be made a type feature. It stubbornly resists reversion through the influence of union of the abnormal with a normal individual.

There is a race prejudice which operates against the transmission of external abnormalities, but which cannot affect that of internal ones. The duplication of a muscle, for instance, would not appear externally, yet might give the animal possessing it some new movement of advantage in the life race. Its tendency to hereditary transmission must be as great as that of an extra finger, while it would escape the checking influence of the race prejudice.

It is equally possible that an extreme development, or an important duplication of brain tissue, might appear. Slight deficiency or excess of brain tissue is often transmitted through several generations. The former is in the line of reversion towards an ancestral type, or towards some new degraded type, in which organs belonging to several types may exist in combination. The latter is in the line of development of a new type. Extreme variations in this respect are, of course, exceedingly unlikely to be transmitted. But minor variations are frequently transmitted, and it is impossible to say where the line must be drawn. It is quite possible that considerable anomalies may be occasionally transmitted to descendants. An animal might appear with an excessive brain development, or some brain duplication, yet this not be sufficient to destroy the due balance of the organs, or prevent sexual fertilization. And if such an excess were transmitted through several generations, the animals possessing it might, through superior mental ability, crowd out and replace their less able kindred. Possibly in this manner the long reach upward, from ape to man, might be made almost in a single step.

In organic, as in inorganic nature, there are dividing lines, on opposite sides of which weights tend to fall in opposite directions; or water-sheds, which divert the flow of waters to opposite oceans. An animal species may be exactly adapted to surrounding conditions; but a scion of this species may arise not fully adapted to the environment, and it may transmit its anomalous organization through several generations. If the anomaly be a marked one, a struggle is at once set up within the organism. The organic formation of the animal may not be out of accord with natural conditions. Its anomalous feature may be a decidedly advantageous one. Two tendencies exist within the animal, the tendency to conform to the hereditary habits of its type, and the tendency to avail itself of its new powers. There is a struggle between instinct and reason. Some divergence of habits will be very likely to arise, but not so great as there would be were there no instinctive pull towards the normal habits. If the anomaly be transmitted to offspring, the newly gained habits will also be transmitted; therefore every successive transmission favors the formation of a new adaptation to nature. If the change of organization be a muscular one, and a new movement of some part of the outer body be gained, the use of this movement may be of decided advantage to the animal, and if it be transmitted through a sufficient number of generations, new instinctive habits are likely to arise. If it be a nervous one, some new mental energy may be gained, which must struggle with the hereditary muscular habits. It may be a new phase of nutritive or reproductive energy, but whatever it be it is not impossible but it may succeed in establishing itself against the two opposing influences of instinctive habits normal to the species, and of imperfect reproductive energy.

Such an anomaly might be preserved without change in the surrounding conditions of nature, but would be specially likely to be preserved under such changes in the environment as favor variation in the normal offspring of the species. And by this means new species might arise through single great deviations from the specific type, as well as in the more general method of successive slight deviations.

The chances are, doubtless, strongly against the hereditary preservation of an anomalous feature, while the natural conditions remain unchanged. But it seems quite possible that if a marked change in conditions occur, or if a group of animals of some fixed type be moved to a new locality, to whose conditions they are not fully adapted, considerable organic changes might take place rapidly instead of with the slowness ordinarily supposed. For it is certainly not improbable that the inharmony between the animal and its surrounding conditions might strongly affect its internal organization and thus favor the formation of anomalous embryos. And some of these abnormal offspring, considerably varied from the normal type, might be particularly adapted to the surrounding conditions. If so, they would have an advantage over the normal forms, and their new powers would have a like advantage over the hereditary or instinctive tendencies.

Such an anomaly, if transmitted to descendants, would possibly constitute a specific change in organization at a single step, while the new, well adapted variation might rapidly replace the old, ill adapted normal form.

The evolution of new species in this manner could but rarely occur; yet every anomaly of excess is a new step forward in organic specialization, and if preserved must yield an advanced species. When it does occur a decided change in organization takes place immediately instead of gradually as in the variation of mature individuals. Instead of natural selection of slight differences in mature beings doing all the work in the evolution of species, the process of germinal selection may be the primary force at work. The lever of change is fixed lower down in the line of development, and thus its lifting power is greatly enhanced. The origin of every new species may be a matured monstrosity, representing either a partial reversion to ancestral conditions, or the gaining of new and increased powers. Upon this long step outward from the normal, selection at once acts. The animal may perish. Its hereditary tendencies may hinder the employment of its special powers, and thus cause them to become gradually obliterated. The sexual union of such an animal with a normal one, must also tend to obliterate the points of distinction. Yet in rare cases all these difficulties may be overcome. The animal may produce offspring possessing and employing its new powers. The exercise of these powers will gradually overcome the hereditary tendencies, produce a new accord with nature, and draw the new form further and further away from its race, until a specific difference is fully established.

The hypothesis of natural selection, as usually advanced, has proved insufficient to explain all the phenomena of organic variation. This hypothesis of germinal selection may serve to fill the gap and explain the lack of linking forms between species.

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EDITORS' TABLE.

EDITORS: A. S. PACKARD, JR., AND E. D. COPE.

—— Progress moves slowly in the Philadelphia Academy. Since the election of a scientific man to the presidency of the institution, several opportunities of recognizing that class of its members have occurred, and have been thrown away. Perhaps the anti-scientifics only needed a reputable figure-head to place them in a more impregnable position than ever. The deaths of two curators of no scientific reputation or position, was an excellent opportunity to honor some of the younger scientists of our city who have already made their mark. But with the grip of the dying miser on his gold, the residuary legatees of reaction